

# CLAIMS

## What is Claimed is:

1. An implantable cardiac stimulation device comprising:  
5 a first sensor that is capable of sensing intrinsic cardiac activity and generating corresponding signals;  
circuitry that is connected to the sensor to receive signals from the sensor, wherein the circuitry is operative to process the signals to determine an intrinsic heart rate;  
10 a second sensor that is capable of sensing a physiologic parameter;  
circuitry that is connected to the second sensor and that is operative to determine a potential sleep apnea condition based on the sensed physiologic parameter;  
15 one or more pulse generators that are capable of generating cardiac pacing pulses to be delivered to the patient; and  
a control circuit that is responsive to detection of the potential sleep apnea condition to control the one or more pulse generators to pace at an overdrive pacing rate based on the intrinsic  
20 heart rate.

2. An implantable cardiac stimulation device according to Claim 1 wherein the control circuit comprises an executable control logic that includes a logic capable of detecting a sleep condition, and a logic  
25 capable of controlling the one or more pulse generators with a timing based on the sensed intrinsic cardiac electrical phenomena to overdrive the intrinsic cardiac electrical phenomena to prevent sleep apnea.

3. An implantable cardiac stimulation device according to Claim 1  
30 wherein the control circuit comprises an executable control logic that detects a sleep apnea condition and controls the one or more pulse

204720 E50/2007

generators with a timing based on the sensed intrinsic cardiac electrical phenomena and is capable of terminating the detected sleep apnea condition.

5           4. An implantable cardiac stimulation device according to Claim 1 wherein the control circuit comprises an executable control logic including a logic for detecting a sleep condition based on the physiological parameter, and a logic capable of controlling the one or more pulse generators with a timing based on the sensed intrinsic cardiac electrical  
10           phenomena to overdrive the intrinsic cardiac electrical phenomena to prevent sleep apnea.

              5. An implantable cardiac stimulation device according to Claim 1 wherein the control circuit comprises an executable control logic that  
15           detects a sleep apnea condition based on the sensed physiological parameter and controls the one or more pulse generators with a timing based on the sensed intrinsic cardiac electrical phenomena that is capable of terminating the detected sleep apnea condition.

20           6. An implantable cardiac stimulation device according to Claim 6 wherein the abnormal breathing pattern is indicative of Cheyne-Stokes respiration.

              7. An implantable cardiac stimulation device according to Claim 1  
25           further comprising:  
              a sensor implantable into a chamber of the heart that is capable of sensing intrinsic electrical phenomena; and  
              a pulse generator of the one or more pulse generators that is capable of generating pacing pulses based on timing of the  
30           sensed intrinsic electrical phenomena to dynamically overdrive the intrinsic electrical phenomena, the generated

20250720 10:53:02

cardiac pacing pulses being capable of preventing sleep apnea.

8. An implantable cardiac stimulation device according to Claim 1  
5 wherein the control circuit comprises an executable control logic that is  
capable of distinguishing between a rest or sleeping condition and a  
waking condition of a patient based on the physiological parameter,  
confirming a sleep apnea condition based on the physiological parameter,  
and generating pacing pulses based on timing of the sensed intrinsic  
10 cardiac electrical phenomena to dynamically overdrive the intrinsic  
cardiac electrical phenomena, the generated cardiac pacing pulses being  
capable of preventing sleep apnea.

9. An implantable cardiac stimulation device according to Claim 1  
15 further comprising:  
an impedance sensor that is capable of sensing one or more  
respiration parameters; and  
wherein the control circuit is coupled to the one or more pulse  
generators and to the impedance sensor, the control circuit  
20 comprising an executable control logic that is capable of  
distinguishing between a sleeping condition and a waking  
condition of a patient based on the one or more respiration  
parameters, and generating pacing pulses based on timing  
of the sensed intrinsic cardiac electrical phenomena to  
25 dynamically overdrive the intrinsic cardiac electrical  
phenomena, the generated cardiac pacing pulses being  
capable of preventing sleep apnea.

10. An implantable cardiac stimulation device according to Claim 1  
30 further comprising:  
an oxygen sensor that is capable of measuring blood oxygen  
concentration; and

204720-0502001

5 wherein the control circuit is coupled to the one or more pulse  
generators and to the impedance sensor, the control circuit  
comprising an executable control logic that is capable of  
detecting a sleep apnea condition of a patient based on a  
blood oxygen concentration indicative that blood oxygen  
level is depressed during sleep, and generating pacing  
pulses based on timing of the sensed intrinsic cardiac  
electrical phenomena to dynamically overdrive the intrinsic  
cardiac electrical phenomena, the generated cardiac pacing  
10 pulses being capable of terminating sleep apnea.

11. An implantable cardiac stimulation device according to Claim 1  
further comprising:

15 a carbon dioxide sensor that is capable of measuring blood carbon  
dioxide concentration; and

wherein the control circuit is coupled to the one or more pulse  
generators and to the impedance sensor, the control circuit  
comprising an executable control logic that is capable of  
detecting a sleep apnea condition of a patient based on a  
20 blood carbon dioxide concentration indicative that blood  
oxygen level is depressed during sleep, and generating  
pacing pulses based on timing of the sensed intrinsic  
cardiac electrical phenomena to dynamically overdrive the  
intrinsic cardiac electrical phenomena, the generated  
25 cardiac pacing pulses being capable of terminating sleep  
apnea.

12. An implantable cardiac stimulation device comprising:  
a sensor that is capable of sensing intrinsic cardiac electrical  
30 phenomena;

20170520-250240F

204F20-550200T  
5 a heart rate determination device that is connected to the sensor  
and is operative to determine an intrinsic heart rate based  
on the sensed intrinsic cardiac electrical phenomena;  
circuitry that is capable of generating cardiac pacing pulses at an  
overdrive pacing rate based on the intrinsic heart rate; and  
10 a sleep apnea determination device that is operative to determine  
when a potential sleep apnea condition exists, and that is  
responsive to the potential sleep apnea condition to control  
the circuitry to generate pacing pulses at the overdrive  
pacing rate.

15 13. An implantable cardiac stimulation device according to Claim  
12 wherein the sleep apnea determination device comprises a controller  
that comprises an executable control logic that includes a logic capable of  
detecting a sleep condition, and a logic capable of controlling one or more  
pulse generators with a timing based on the sensed intrinsic cardiac  
electrical phenomena to overdrive the intrinsic cardiac electrical  
phenomena.

20 14. An implantable cardiac stimulation device according to Claim  
12 further comprising:  
a physiological sensor that is capable of sensing a physiological  
parameter; and  
wherein the sleep apnea determination device comprises a  
25 controller coupled to the sensor, the controller comprising an  
executable control logic that detects a sleep apnea condition  
based on the sensed physiological parameter and controls  
one or more pulse generators with an overdrive pacing rate  
based on the sensed intrinsic cardiac electrical phenomena.

30 15. An implantable cardiac stimulation device according to Claim  
12 further comprising:

a physiological sensor that is capable of detecting an abnormal  
breathing pattern; and  
wherein the sleep apnea determination device comprises a  
controller coupled to the physiologic sensor, the controller  
comprising an executable control logic that detects the  
abnormal breathing pattern and controls one or more pulse  
generators with a timing based on the sensed intrinsic  
cardiac electrical phenomena.

16. An implantable cardiac stimulation device according to Claim  
15 wherein the abnormal breathing pattern is indicative of Cheyne-Stokes  
respiration.

17. An implantable cardiac stimulation device according to Claim  
12 further comprising:  
an impedance sensor that is capable of sensing one or more  
respiration parameters; and  
wherein the sleep apnea determination device comprises a  
controller coupled to the impedance sensor, the controller  
comprising an executable control logic that is capable of  
detecting a sleep apnea condition of a patient based on the  
one or more respiration parameters, and generating pacing  
pulses based on timing of the sensed intrinsic cardiac  
electrical phenomena to generate overdrive pacing pulses.

18. An implantable cardiac stimulation device according to Claim  
12 further comprising:  
an oxygen sensor that is capable of measuring blood oxygen  
concentration; and  
wherein the sleep apnea determination device comprises a  
controller coupled to the impedance sensor, the controller  
comprising an executable control logic that is capable of

20170520-25022001

5 detecting a sleep apnea condition of a patient based on a blood oxygen concentration indicative that blood oxygen level is depressed during sleep, and generating pacing pulses based on timing of the sensed intrinsic cardiac electrical phenomena to dynamically overdrive the intrinsic cardiac electrical phenomena, the generated cardiac pacing pulses being capable of terminating sleep apnea.

10 19. A method of operating an implantable cardiac stimulation device comprising:  
monitoring cardiac activity;  
determining an intrinsic heart rate based on the monitored activity;  
monitoring a physiologic parameter for a potential sleep apnea condition; and  
15 generating overdrive pacing pulses at an overdrive pacing rate in response to determining a potential sleep apnea condition, wherein the overdrive pacing rate is based on the intrinsic heart rate.

20 20. A method according to Claim 19 further comprising:  
detecting a sleep condition; and  
generating the overdrive pacing pulses upon detecting the sleep condition.

25 21. A method according to Claim 19 further comprising:  
detecting a sleep apnea condition; and  
generating the overdrive pacing pulses upon detecting the sleep apnea condition.

30 22. A method according to Claim 19 further comprising:  
detecting Cheyne-Stokes respiration; and

204720 550200T

generating the overdrive pacing pulses upon detecting the Cheyne-Stokes respiration.

23. A method according to Claim 19 further comprising:  
5 sensing a physiological parameter;  
distinguishing between a sleeping condition and a waking condition  
of a patient based on the sensed physiological parameter;  
generating cardiac pacing pulses based on timing of the sensed  
intrinsic cardiac electrical phenomena; and  
10 dynamically overdriving the heart.

24. An implantable cardiac stimulation device comprising:  
means for determining an intrinsic heart rate;  
means for detecting a potential sleep apnea condition; and  
15 means for overdrive pacing the heart at a rate based on the  
intrinsic heart rate in response to detection of a potential  
sleep apnea condition.

25. An implantable cardiac stimulation device according to Claim  
20 24 wherein the means for detecting a potential sleep apnea condition  
comprises means for detecting a sleep condition.

26. An implantable cardiac stimulation device according to Claim  
24 wherein the means for detecting a potential sleep apnea condition  
25 comprises means for detecting a sleep apnea condition.

20170520-02442